NATIONAL SCIENCE FOUNDATION
Division of Science Education Development
and Research

ORIGINAL

## DEVELOPMENT IN SCIENCE EDUCATION

# Pre-College Mathematics Education Using Computers

Project Awards
Fiscal Year 1980

The Development in Science Education (DISE) Program supports science course and curriculum development projects of national consequence aimed at all levels of students (kindergarten through continuing education) and in both formal (classroom) and informal (museums, etc.) settings.

Twenty of the projects that the DISE program supported during fiscal year 1980 involve pre-college mathematics using computers. Mathematics educators may find descriptions of these projects helpful.

On the following pages, these projects are listed by State and Institution. Project descriptions are on the respective subsequent pages. Some projects received partial funding from the Research in Science Education (RISE) Program because of a research element in the project. Such projects will be marked "RISE/DISE." Some projects received partial funding from the National Science Foundation/National Institute of Education Improvement of Mathematics Education Using Information Technology Program. Those projects will be marked "NSF/ NIE." Projects funded totally by DISE will be so designated.

Project summaries for all projects awarded during fiscal year 1980 by the Division of Science Education Development and Research are contained in publication No. SE 81-80, Source Book of Projects, available from Forms and Publications, National Science Foundation, Washington, DC 20550.

Other publications listing awards made in FY 1980 are:

Research in Science Education (RISE) Program Project Awards (SE81-54)

Development in Science Education (DISE) Program Project Awards (SE81-52)

NSF/NIE Make Awards to Improve Math Education
by Using Low-Cost Information Technology
(Press Release)

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This report presents a listing of awards made by the Division of Science Education Development and Research (SEDR) during fiscal year 1980. All references made in this document to actual award amounts are subject to adjustment by financial statements prepared by NSF at the close of fiscal year 1980.

Division-initiated funding actions excluded from this report are:

Purchase Orders
Funds for Personnel (Intergovernmental Personnel Act)
International Travel Awards

Awards which received support from organizations within or outside the Division show the source of that support.

The following definitions apply:

"Award" refers to financial support given in the form of a grant, contract, or other arrangement, depending upon the nature of the research or development work to be completed and the terms of performance.

"Principal Investigator" refers to the individual designated by the awardee (and approved by NSF) who is responsible for the scientific or technical direction of the project.

"Institution" refers to any college, university, public or private laboratory, industry, or other organization, whether operating for profit or on a non-profit basis, as well as State and local governments and Federal organizations.

Note: Data for this report were taken from program records and therefore may differ from official National Science Foundation source documents which are generated from the Management Information System data base containing different inclusions/ exclusions.

The reader is reminded that the primary source of further information on a project is the Principal Investigator in each instance, who may be reached at the academic address given.

# Project Summaries

# Pre-College Mathematics Education Using Computers

## Fiscal Year 1980

XIII

Advanced Learning Technology
13800 Skyline Boulevard
Woodside, CA 94062

Ann Piestrup

Early Learning (Grades 2-3) of Geometry and Logic, Using Microcomputers

Young children can learn mathematics in a playful, interactive manner using today's microcomputers. Games, inquiry learning sequences and puzzles can be programmed on a low-cost, powerful computer with color graphics, natural sounding speech, music, and a variety of input devices. Children can use a joystick, a graphics tablet, light pen and a special children's keyboard to explore mathematics concepts. The project will develop microcomputer software which will enable children aged 7 and 8 to discover geometry concepts and to develop logical thinking. The microcomputer programs will be paced and sequenced to provide a dynamic learning environment for young children. Some computer programs will be prepared in three versions: with standard English, Black standard English, and Spanish voice prompts. Teacher's manuals for each program will be written in Spanish and English. The programs will be designed for gifted children as prototypes of a mathematics enrichment curriculum on microcomputers. Commercial publication will be sought.

| | |
|---|---|
| Award Number: | SED 80-12510 (NSF/NIE) |
| Award Amount: | $130,000 |
| Duration: | September 10, 1980 -<br>February 28, 1982 |

University of California, Berkeley
Lawrence Hall of Science
Berkeley CA 94720

John David Miller

Elementary Mathematics Concepts with Calculators: Microcomputer Based Modules for Teachers, Parents and the Public

For over four years, professional mathematics educators have urged the use of calculators in mathematics education. Presently, 90% of elementary classrooms do not use calculators to any significant degree. This project will develop a pilot, three-hour instructional program for using calculators in elementary mathematics teaching. The audience for this instruction will be 4th, 5th, and 6th grade teachers; support personnel; parents; and members of the public. The delivery system for this instruction will consist of three highly interactive microcomputer-based programs. The programs will enable teachers to begin using many kinds of calculators together with any regular math text. A subset of this instruction will be for parents and the general public--to explain to them the use of calculators in mathematics teaching and to enlist support for the teachers.

Award Number: SED 79-19000 (DISE)

Award Amount: $98,027

Duration: May 15, 1980 - April 30, 1982

San Francisco State University
1640 Holloway Avenue
San Francisco, CA 94132

Dr. Diane Resek

Mathematics Network Curriculum Project for Middle School Teachers and Students

This project, for the introduction of microcomputers into the middle school mathematics curriculum, has three objectives: the development of seven curriculum prototypes (Units), a model for the teachers, and the development/implementation of a computer communications system (Network) to bring together the separate classrooms. The computer activities will stem from classroom activities that utilize the manipulation of real objects and/or the activities of the students themselves. Each Unit incorporates five elements: games; simulations; classroom activities; data storage, retrieval and processing; and interclassroom interaction. Dynamic software will be developed to provide both structure and freedom for student manipulation of data and interaction with the mathematical content and concepts. The Network will provide for interaction of students and classrooms with each other, teachers with each other, and all of these with the university data base. The interaction will enhance participation and motivation of both students and teachers. The project will disseminate information at professional meetings and will explore the possibilities of commercial publication of the materials.

Award Number: SED 80-12465 (NSF/NIE)

Award Amount: $130,811

Duration: September 17, 1980 - February 28, 1983

University of Colorado
School of Education
Boulder, CO 80309

Marc Swadener

Personal Computers and Cross-Age Instruction

This project will develop an instructional strategy combining use of personal computers and cross-age instruction. The development plan includes identifying 60 low-achieving sixth grade students and 60 non-math/science oriented, able tenth grade students. (Half of each group will be randomly assigned to experimental control groups.) During the first semester of a two-semester program, 30 tenth graders will study specific areas of math weakness of 30 sixth graders and will develop microcomputer courseware for them. Each tenth grader will tutor one sixth grader during the second semester, using and further developing courseware. The anticipated results of the project include an improvement in math and problem-solving skills of both groups of students and increased enrollment in math and science classes beyond grade ten. The project will produce a tested instructional strategy, a curriculum for high school students and computer software.

Award Number: SED 79-18974 (DISE)

Award Amount: $84,917

Duration: September 15, 1980 -
February 28, 1983

Georgia Institute of Technology
225 North Avenue
Atlanta, GA 30332

Les A. Karlovitz

Microcomputer-Based Strategies for Mathematics in Junior High and High School

This project will develop computer programs called IDP's (interactive demonstration programs) for use on microcomputers capable of generating high resolution video graphics to treat key topics in traditional junior high and high school mathematics courses--primarily general mathematics, algebra, geometry, and and calculus. The programs will apply the technology to the tasks of computation, graphical display, and simulation in order to clarify and explain the subject matter. The classroom component of the project is complemented by a laboratory component in which students experiment individually with the programs and carry on related activities.

The primary product of the project will be the demonstration of a teaching model which makes use of computer programs for classroom demonstration and laboratory use in mathematics courses. The programs themselves, which will be available when the project is completed, will be designed to bring ideas and numbers together more effectively for the understanding of mathematical concepts and procedures, promote classroom participation by virtue of the interactive nature of the programs, provide multiple viewpoints and contexts for the treatment of the given topic, and allow for a useful redistribution of the teachers' time. Teachers from the Atlanta public school system will be actively involved in the planning and development of the IDP's to ensure the quality and effectiveness of the programs. A distribution network for the materials will be provided by the Southeastern Consortium for Minorities in Engineering. The project is designed for future expansion to other courses and grades and to a large geographical area.

Award Number: SED 80- 12649 (NSF/NIE)

Award Amount: $88,800

Duration: August 1, 1980 - October 31, 1982

University of Florida
College of Education
360 Norman Hall
Gainesville, FL 32611

Mary Grace Kantowski

## Instruction for Problem Solving Using the Microcomputer

This project will develop prototypes of instructional materials for nonroutine and real problem solving to be used with a microcomputer. The effectiveness of these materials in promoting growth in the problem-solving ability of students in grades five through twelve will be studied. Prototypes will be developed in two areas of mathematical problem solving (geometry and number theory) as well as in real problem solving so that multiple aspects of the potential of the microcomputer can be exploited. The graphic capabilities may be used to great advantage in the geometry problems, and the iterative and calculator capabilities are most useful in number theoretic problems. Interaction with the computer will be emphasized. The comprehensive series will include introductory videotapes (or intelligent discs) and software packages in problem-solving techniques. Supplementary printed materials will be available in some cases. An important aspect of the final product will be a collection of sequences of similar problems. Hints or cues will be provided for a number of possible solution paths. In addition, each set of problems will include supplementary instruction in key content areas as well as useful algorithms. Materials will be submitted to consultants for critical evaluation. Programs will be demonstrated in NCTM meetings at St. Louis in 1981 and Toronto in

1982. Progress reports and materials will be distributed to those interested in mathematics education.

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| Award Number: | SED 80-12466 (DISE) |
| Award Amount: | $110,322 |
| Duration: | August 1, 1980 - October 31, 1982 |

University of Illinois
Urbana, IL 61801

Sharon Dugdale

Prototype Microcomputer Courseware for Teaching High School Algebra

This project will develop microcomputer courseware to teach basic algebra concepts to secondary students (grades 9-12). Materials will be developed to teach recognition of general functional relationships and graphing of linear and quadratic equations. The materials will use an "intrinsic models" approach. This approach uses motivating activities which are direct expressions of the underlying mathematics such as games based on the mathematical principles involved. The materials will be designed for and tested on a color graphics microprocessor-based system which uses a standard color television set, and a floppy disk for program storage. This hardware has capabilities which can be expected to be widely available in a few years' time.

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| Award Number: | SED80-12449 (DISE) |
| Award Amount: | $111,300 |
| Duration: | July 15, 1980 - June 30, 1982 |

Education Development Center, Inc.
55 Chapel Street
Newton, MA 02160

Judah L. Schwartz

Application of Dimensional Analysis to Middle School Mathematics Using Microcomputer and Print Materials

This project will develop a collection of tested mathematical word problems which will be available both in printed form with graphics and in the form of interactive computer programs for use with a microcomputer. The problems will be set in contexts that are interesting to junior high school students. The approach to problem solving will be based on the technique of dimensional (semantic) analysis commonly used in university-level physics and engineering. A core group of six to ten teachers in the Boston Area will collaborate closely with project staff in the development of materials and will test materials initially. A larger group of 50 teachers with access to microcomputers in several urban areas around the country will then receive all materials and have complete discretion as to their use. Evaluation will be based on the extent to which these teachers voluntarily use the materials provided, and the responses of the teachers and their students after using them. The project will also produce a report presenting insights gained on the following issues in the course of developing and testing the materials: (1) the generation of a computer-based curriculum in mathematics and other subjects; (2) the interaction of printed and computerbased materials; (3) computer-generated printed materials custom tailored to particular student interests; (4) the attitudes of teachers toward the present and future roles of computers in education; and (5) the training of teachers to use computers to their own ends, both as professional teachers and as functioning adults in society.

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| Award Number: | SED80-12611 (DISE) |
| Award Amount: | $156,101 |
| Duration: | September 1, 1980 -<br>September 30, 1982 |

Massachusetts Institute of Technology
77 Massachusetts Avenue
Cambridge, MA 02139

Seymour Papert

Interest Worlds: Precollege Mathematics in a Computer Culture

This project will develop an alternative to the traditional uniform mathematics curriculum. The new model of education will be computer-based "interest worlds." These interest worlds will serve as significant routes into the achievement of "computer literacy" on a broad scale. The key idea behind the project is: If people have developed a serious interest and significant expertise in some activity and its associated body of knowledge, then it should be possible to design computer systems that help them pursue that activity and at the same time draw on their expertise and emotional attachment to support mathematics learning. Four interest worlds will be developed: Words World, Games World, Music World, and Animation World. The interest worlds will be tested in a 6-week summer program for 24 mid-elementary to junior high school youngsters.

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| Award Number: | SED80-12648 (NSF/NIE) |
| Award Amount: | $163,434 |
| Duration: | September 1, 1980 - July 31, 1982 |

St. Olaf College
Northfield, MN  55057

Lynn Arthur Steen

Microcomputer Instructional Units (for 11th and 12th Grade Mathematics) Using Simulation of Mathematical Modelling

Three prototype instructional units will be developed for microcomputers, each using simulation of mathematical modelling as a vehicle with which students can explore the geometrical and physical bases of mathematical relationships. The simulation programs will employ color graphics (with a graphic input pad) to illustrate physical and geometrical processes. Students will use the programs as experiments, trying different parameters and conditions, in order to collect data and formulate conjectures. The program packages will permit students to test their conjectures for consistency with the simulations, and will suggest exploration of possible sources of error. The materials will be tested in high school, college, and in adult continuing education classes. Each program package will be a self-contained instructional unit on some topic illustrating mathematics ordinarily encountered in grades 11 and 12. Each will be accompanied by a supplementary pamphlet suggesting problems, projects, and further reading.

Award Number:  SED80-12463 (NSF/NIE)

Award Amount:  $54,184

Duration:  July 1, 1980 - June 30, 1983

All Indian Pueblo Council
1015 Indian School Road
Albuquerque, NM 87197

Judith A. Hakes

Computer Storytelling Mathematics for Pueblo Indian Upper-Elementary Level Students

This project will develop an alternative, computer-based learning unit in mathematics and science for upper-elementary level Pueblo Indian students. The project will produce and field test a four- to six-week unit entitled "Pueblo Uses of Energy" which fuses mathematical problem solving with science content related to the daily lives of the Pueblo students. The major mode of instruction will be the microcomputer interfaced with a tape recorder. Instructional programs will be designed to introduce content and skills in a storytelling format which capitalizes on a specific learning style of Pueblo culture. The project will be accomplished in two, six-month phases: 1) Design; and 2) Field development, revision and dissemination. The computer programs, audio tapes, and printed materials developed will be disseminated through the Education Division of the All Indian Pueblo Council to Bureau of Indian Affairs schools and other educational programs. Materials will also be available at the American Indian Bilingual Education Center at the University of New Mexico. Results of the project will be presented in journal publications.

Award Number: SED80-12482 (NSF/NIE)

Award Amount: $59,444

Duration: September 19, 1980 - February 28, 1982

Educational Solutions, Inc.
80 Fifth Avenue
New York, NY 10011

Dr. Caleb Gattegno

Microcomputer Courseware to Develop Insight into Arithmetic Using Perceivable Algorithms

The project presents a new way of using microcomputers for teaching mathematics. The prototype will be field tested with first and second graders and early adolescents (middle school age) in predominantly minority public schools in New York City. The ultimate target audience will be elementary and middle school students. The approach to be used is based on learning through insight rather than drill. The computer is used to generate insight in students by interacting with them in such a way that their attention is focused on mathematical relationships and transformations. Prototype courseware for generating insight and skill in numeration, addition, and subtraction will be produced, field tested, and refined.

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| Award Number: | SED80-12612 (DISE) |
| Award Amount: | $52,000 |
| Duration: | September 15, 1980 -<br>July 31, 1982 |

Rensselaer Polytechnic Institute
Mathematical Sciences Department
Troy, NY 12181

Edith H. Luchins

Improving Spatial Skills in Pre-College Mathematics through Computer Graphics

This project will develop and test experimental educational materials intended to improve mathematical problem solving by training spatial visualization and orientation. Spatial skills have been shown to be good predictors of mathematical performance and grades in mathematics courses and to be important in certain occupations. Among modern technologies, computer graphics has special potential as a tool in spatial visualization and orientation training. This project will develop and produce software (which will be available at the end of the project) to generate a variety of instructional courseware. Students will interact with subject matter using individual computer graphics systems. The computer programs will evaluate student responses and adapt the training sequence. Moreover, this software will enable teachers to design new training experiences without special knowledge of computing. Testing of materials will be done at a public and a private high school. Pre- and post-training testing of spatial and mathematical abilities will be administered to experimental and control subjects. Since sex differences in spatial abilities have been reported widely, the project will compare the changes in spatial skills shown by males and females.

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| Award Number: | SED80-12633 (NSF/NIE) |
| Award Amount: | $124,769 |
| Duration: | August 15, 1980 - July 31, 1982 |

Wittenberg University
Springfield, OH 45501

William H. Kraus

### The Use of Microcomputers for Mathematics Instruction in Grades 1-4

This project will develop 10 to 15 computer games to be used as supplements to mathematics instruction in grades 1 through 4. The computer will be used as a learning center in the classroom. The games to be developed are based on typical game strategies used with older students: practice in skills; applications of mathematics; and problem solving. Games will be designed for both small and large group use. The mathematical content of the programs would cover the 10 basic skill areas identified by the National Council of Supervisors of Mathematics. Development of the program would stress the following: (a) appropriateness of mathematical content; (b) ease of program use; and (c) use of color graphics and animation for increased motivation, user-involvement, and effectiveness of communication. Elementary teachers will be involved in the development of the programs, and the programs will be field-tested in public schools.

Award Number: SED80-12268 (NSF/NIE)

Award Amount: $25,048

Duration: July 1, 1980 - December 31, 1982

Drexel University
Philadelphia, PA 19104

John H. Staib

Computer Graphics in a High School Mathematics Laboratory

This project will develop a series of microcomputer-based mathematics experiments designed to accompany a high school course in elementary mathematical functions. The experiments will constitute a laboratory course which will make use of interactive computer graphics as a means for developing mathematical insights and for otherwise motivating and enhancing the learning of mathematics. These experiments will be designed to encourage the use of inductive reasoning processes.

A team of mathematicians, mathematics educators, and computer scientists will design, develop, and field test the laboratory course. The team will produce the necessary software, a student laboratory manual with worksheets, and a teacher's guide. The project will be a cooperative one including the school district of Philadelphia. The school district will contribute personnel and make possible a classroom test of the materials.

Results of the project will be presented at local and national professional meetings. The materials will be demonstrated at in-service courses for teachers in the Philadelphia area and will be made available to other school systems and individual teachers throughout the country.

Award Number: SED80-12532 (DISE)

Award Amount: $123,000

Duration: August 1, 1980 -
September 30, 1982

University of Pittsburgh
1028 Cathedral of Learning
Pittsburgh, PA   15261

Lauren B. Resnick

### Semantics of Arithmetic: Teaching Understanding and Computational Skill Via Computer

This project will use small computers to provide basic instruction in arithmetic. The instruction will connect performance of computational algorithms to understanding of the underlying mathematical principles. The instructional program will be based on principles derived from empirical study and theoretical analysis of an important part of elementary school mathematics, i.e., arithmetic procedures that depend upon a knowledge of place value. The program builds understanding of these procedures by helping the child develop detailed correspondence between two systems for representing numbers (using blocks as well as written notation) and arithmetic operations in those systems. The program will provide practical instruction, usable in classrooms at reasonable cost, as well as an opportunity to test the validity of a developing theory of the origin of arithmetic errors and ways of preventing these errors through meaningful instructions.

Award Number:   SED80-12511 (RISE/DISE)

Award Amount:   $152,256

Duration:   September 1, 1980 -
August 31, 1982

Christian Brothers College
650 E. Parkway South
Memphis, TN 38104

Joel Baumeyer

Using a Visual Technique to Teach High School Students the Concept of Variables in Polynomials

This project will assist students who have difficulty in the manipulation of the basic symbols used in introductory algebra. This difficulty leads to a failure to understand the true nature of a polynomial and precludes the further study of mathematics. Four objectives are to be attained: (1) The student will learn to use "polyboxes" in order to understand the concept of a variable polynomial (the "polybox" is a visual device that replaces the variable "x" in a way that is visually more obvious than standard notation); (2) Software for computer programs will be written to use "polyboxes" with a visual display on an interactive display terminal which includes feedback from a small computer; (3) Students will use the software in lessons devised as a module for classroom instruction or self-paced instruction to learn the manipulation of basic polynomials and to obtain a better understanding of the nature of a polynomial; and (4) The module, consisting of 5 lesson plans including the typical teacher aids of performance objectives and tests and written in a programmed learning self-paced mode, will be prepared and packaged. This project is geared to the 11th and 12th grade student taking algebra and/or junior college student or college freshman taking introductory college algebra. The evaluation and dissemination will take place in a pilot classroom with students and in a workshop with secondary school teachers of algebra. Teachers will evaluate this project relative to the usefulness of the module in their individual classrooms.

Award Number: SED80-12518 (DISE)

Award Amount: $34,106

Duration: September 1, 1980 -
February 28, 1983

WICAT, Inc.
Learning Design Laboratories
1160 South State, Suite 10
Orem, Utah 84057

C. Victor Bunderson

Mental Errors in Arithmetic Skills: Their Diagnosis and Remediation in Pre-College Students

This project will study methods of diagnosing consistent mental errors (termed cognitive bugs) exhibited by students in elementary arithmetic, the frequency and stability of such errors, and ways to remedy the errors using a microcomputer. Three populations will be involved in the study: third to fifth graders in Orem, Utah; fourth to sixth graders in Salt Lake City (including students from the middle class, urban poor, and minority groups); and teenaged juvenile delinquents in Salt Lake City alternative schools. The objectives are the following: (1) to develop cognitive diagnostic models and tests in subtraction, multiplication, and addition of fractions; (2) to obtain data to determine the need for computerized diagnostic testing for each of the three areas; (3) to develop, if the cognitive bugs are frequent enough and stable, microcomputer-based diagnostic tests to follow paper and pencil screening tests; (4) to develop microcomputer-based remediation programs to structure a remedial interchange between a student and tutor.

The diagnostic and remedial programs will be evaluated in field experiments. The materials will be made available to interested parties upon request. Research findings will be disseminated via presentation at national conferences and publication in professional journals.

Award Number: SED80-12500 (RISE/DISE)

Award Amount: $141,544

Duration: September 15, 1980 -
August 31, 1982

Virginia Commonwealth University
901 West Franklin
Street Richmond, VA 23284

J. Richard Morris

Graphing in High School Level Algebra and Trigonometry

A software package of 15 to 20 graphing lessons intended for use on a computer graphics terminal will be developed by three members of the Mathematical Sciences Department at Virginia Commonwealth University. This package will be used by students on an individual and personalized basis with the help of a qualified teaching assistant. The software will augment existing courses in elementary algebra, intermediate algebra and trigonometry. The content of these courses is the same as that found at grade levels 10 through 12. Each lesson in the software package will be written so that the student is an active participant in the graphing process.

Appropriate testing will take place at each stage of development to insure the effectiveness of the graphing lessons. When the software is complete, a control group and an experimental group will be selected from among the groups of students of age 25 or over. Both student achievement and attitude will be assessed. Guidelines established by CONDUIT will be used as a basis of project organization and management. The software and the new knowledge which result from the project will be disseminated.

Award Number: SED80-12447 (NSF/NIE)

Award Amount: $55,494

Duration: July 1, 1980 - December 31, 1982

Carroll College
100 N. East Avenue
Waukesha, WI 53186

Gerald L. Isaacs

## Geometric Visualization: Dynamic Graphics to Develop Mathematical Perception and Intuition in Pre-calculus Students

This project is a joint effort between Carroll College and the Waukesha Public School System. Its primary purpose is to improve the teaching of precalculus courses through the introduction of Geometric Visualization Techniques using the graphics capabilities of low-cost microcomputers and television displays. The approach will be to promote understanding, using geometric representation and interpretation. An equally important goal is to introduce a prototype for designing graphics software to be used throughout mathematics and science education. This software will be designed in such a way as to be easily transported across hardware, graphics devices, and dialects of BASIC. The project revolves around the concept that there are many topics in mathematics that can be better presented and understood with the aid of dynamic graphics. To insure widest possible use, the software will be designed so that the instructor need only turn on the machine and start the program. The package would then present the material in English with appropriate prompts and a clear indication of the options available at each step. The project will be discussed at national meetings, papers will be submitted to professional journals and the courseware and documentation will be disseminated initially through Carroll College and Conduit.

Award Number: SED80-12457 (DISE)

Award Amount: $149,327

Duration: September 15, 1980 - August 31, 1982

END

06-21-82